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The significance of genetic erosion for the extinction of locally endangered plant populations

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Summary

Many endangered species are characterized by small and isolated populations which face an increased probability of extinction through random demographic and environmental forces. In addition, genetic drift and inbreeding are expected to play a role in such populations because their magnitude is inversely related to effective population size. Inbreeding depression on a short-term basis and loss of genetic variation that may be significant for adaptation on a long-term basis may further increase the probability of population extinction. The combined negative effects of isolation and small population size on genetic variation is called genetic erosion. Preservation of genetic variation is therefore often recommended to maintain viable populations, although empirical data concerning the importance of genetic erosion for population extinction are still scarce. The research described in this thesis and a parallel thesis (Ouborg, 1993) addressed the question whether genetic processes are involved in the probability of population extinction for two endangered plant species in The Netherlands: *Scabiosa columbaria* and *Salvia pratensis*.

A basic question is whether the level of genetic variation is already diminished in small populations. At the allozyme level, both the degree of polymorphism and the mean observed number of alleles were positively correlated with population size. Moreover, the allozyme data showed significant genetic differentiation between populations (Chapter 2).

In Chapter 3 it was shown that the complex phenotypes observed for the enzymes GPI and PGD in *S. columbaria* were caused by gene duplications. Electrophoresis of progenies resulting from crossing experiments in *S. columbaria* and of individuals of other species of the family *Dipsacaceae* suggested that a chromosomal segment containing both the loci *Gpi-2* and *Pgd-1* has been translocated in the past.

Also with respect to phenotypic variation large populations were more variable than small populations (Ouborg *et al.*, 1991). The combined results addressing the relationship between population size and level of genetic variation indicated that genetic drift has played an important role in the distribution of genetic variation both within and between populations. The genetic structure of both species resembled an island model of population structure, where populations are geographically isolated from each other with the chance of gene flow between populations being greatly reduced. However, because a significant loss of heterozygosity is expected after prolonged periods of small population size (Chapter 7) and allozyme heterozygosity was not correlated with population size, it was argued that the small populations have not yet experienced reduced size during a large number of generations.

This is not unlikely given the perennial life style of the species. In addition, both species were found to be predominantly outcrossing and outcrossing rates were correlated with plant density rather than population size (Chapters 4

and 5). These results suggested that the inbreeding coefficient may not have increased to a large extent in the small populations. The normal outcrossing habit of the species suggested susceptibility to increasing levels of inbreeding.

The significant levels of inbreeding depression found for both *S. columbaria* (Chapter 6) and *S. pratensis* (Ouborg, 1993) were in agreement with this expectation. The finding that the level of inbreeding depression was not correlated with population size indicated that the small populations still have variation at fitness loci. However, effects of population size on reduction of variation for fitness loci depend on the selection model and the selection intensity assumed and on the number of generations the populations have experienced reduced population sizes (Chapter 7). Since it was argued that the small populations have not experienced reduced population size during a large number of generations, the fitness of individuals in the small populations may be reduced in forthcoming generations by enhancing levels of inbreeding.

Data on inbreeding depression were integrated with demographic data in transition models to evaluate the relative importance of inbreeding depression on the probability of population extinction given the estimated environmental variance (Ouborg, 1993). Although the magnitude of the effect was variable, it was concluded from the analyses that inbreeding depression increases the extinction probability of populations. Loss of genetic variation that may be adaptively significant in future generations may further increase the relative importance of genetic processes for the probability of population extinction. Furthermore, the heterosis effects observed for *S. columbaria* (Chapter 6) and *S. pratensis* (Ouborg, 1993), may reflect recovery from losses of genetic variation in past generations that have reduced current population performance. It seems therefore likely that populations have been reproductively isolated for much longer times than populations have experienced reduced population size. As a result of extensive periods of isolation, populations may have become differentiated for part of the loci that determine individual fitness, whereas they are at the beginning of facing the problems of inbreeding depression for loci that still show genetic variation. It can be concluded therefore that the significance of genetic erosion for the probability of population extinction is underestimated rather than overestimated.

Although additional research is needed for a complete understanding of the long-term viability of populations, effective conservation programs should be initiated on a short-term basis because populations of *S. columbaria* and *S. pratensis* are expected to become extinct within the near future. Based on the available data two measures that seem immediately successful may be proposed. Firstly, adjustment of the mowing regime in populations of *S. columbaria* and *S. pratensis* may reduce the environmental variance and hence increase their viability. Secondly, artificial gene flow between populations may yield fitter progeny. However, reciprocal transplant experiments are needed to reveal further insight in the effects of population hybridization in their natural sites. If individuals have not adapted genotypically to their local sites, population hybridization may lower the probability of population extinction.

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